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BOTTOM POLE STRUCTURE WITH RECESSED SECTION

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FIELD OF THE INVENTION

The invention relates to the general field of magnetic write heads with particular reference to improving track density.

BACKGROUND OF THE INVENTION

To enable increases in the recording density achieved by a magnetic head, the coercivity of the recording media must be increased to overcome the demagnetization field of the magnetic transition. However as the track width decreases, so does the head field. When a high-end hard disk drive (HDD) generates a high data transfer rate, in the order of 1 Gbit/s, or more, not only is greater head field strength required, but there also is a need for a faster flux rise time. In order to achieve a large enough overwrite value, even in such high frequency conditions, the write current is boosted, giving its waveform a large overshoot. This often brings about severe excess saturation of the head and, as a result, adjacent track erasures often occur.

FIG. 1 is a schematic illustration of a conventional planar write head while FIG. 2

shows a closeup of the vicinity of the pole tip region. The design implements a bottom pole 11 (P1), pedestal 12 (P1P) and small throat height region 13 (for flux concentration), which opposes plane top pole 14 (P2)across from write gap 15. These poles are made of soft magnetic materials such as Ni, Co, Fe or their composites. The coil layer is packed onto the P1, and the P2 pole is fabricated on a planar surface to allow good track width control for the P2 tip width definition. The write gap material is a non-magnetic conductor such Cu, Au, Al, Cr, Rh or their composite.

In a conventional planar write head, there are 3 kinds of flux leakage paths between the P1 and P2 pole at the air bearing surface (ABS), as shown is FIG. 3. Leakage path 31 is from P1 to P2, some of which contributes to writing on a magnetic medium. Leakage path 32 is flux flow from the P2 side to the P1 side wall. Leakage path 33 is flux from the P2 side wall to the P1P top boundary (P1 shoulder), because the P1 shoulder is coupled with the P2 side wall magnetically due to the structure. This flux path induces the concentration of the field just at the upper side of the P1 shoulder.

FIG. 4 shows cross track profiles 41-45 of the in-plane field at the upper side of the P1 shoulder for write currents (Iw) of 10, 20, 30, 40, and 60 mA, respectively. The x-axis cross track corresponds to the position illustrated in the lower portion of the figure. This PI shoulder field has greater strength than the gap side field (from the P2 side to P1 side wall), and grows with a shallow peak around the P1 shoulder corner, from which the

shoulder steps down gradually, as the write current increases. From this profile, the P1 shoulder field can become a possible source of erasures, not only at adjacent tracks but also at 2 or 3 tracks away.

The present invention discloses a way to remedy the undesirable problem of the P1 shoulder field in the high write current region.

A routine search of the prior art was performed with the following references of interest being found:

In US 6,553,649, Santini shows recessing of the first pole. Cohen et al disclose etched regions around the first pole in US 5,995,342 while Sasaki describes recessed regions around P1 in US 6,317,289.

SUMMARY OF THE INVENTION

It has been an object of at least one embodiment of the present invention to provide a magnetic write head whose write width does not change significantly at high write currents.

Another object of at least one embodiment of the present invention has been that said write head be able to tolerate severe excess saturation without causing any adjacent track erasure.

These objects have been achieved by indenting P1 away from the ABS so that there is a narrowing of P1 near, but not all the way to, the write gap. This causes the excess flux associated with high write currents to be diverted into P2 instead the P1 shoulder.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGs. 1 and 2 show two views of a planar write head of the prior art.

FIG. 3 shows different leakage paths for the flux between P1 and P2.

FIG. 4 plots the write field (of a prior art device) as a function of distance from the write gap, illustrating how there is a peak in the vicinity of the P1 shoulder.

FIGs. 5a and 5b show a first embodiment of the invention, featuring a recess or indentation in the ABS, which brings about a narrowing of P1 near, but not all the way to, the write gap.

FIG. 6 shows how the structure of FIG. 5 causes excess flux associated with high write currents to be diverted into P2 instead the P1 shoulder.

FIG. 7 plots the write field (of the invented device) as a function of distance from the write gap, illustrating how there is little or no peak in the vicinity of the P1 shoulder.

FIG. 8 plots the maximum write field, as a function of write current, for both the invention and a prior art device.

FIG. 9 plots the P1 shoulder field, as a function of write current, for both the invention and a prior art device.

FIG. 10 plots the magnetic write width, as a function of write current, for both the invention and a prior art device.

FIGs. 11-13 present three alternative embodiments of the invention.

FIGs. 14 and 15 present two possible shapes (ABS view) for P1 .

DESCRIPTION OF THE PREFERRED EMBODIMENTS

We now disclose four embodiments of a novel P1 structure for a planar write head.

FIG. 5a shows the cross section and FIG. 5b the ABS view of a typical example of the new P1 pole structure. The P1 pedestal's ABS includes a partial indentation, or recess, 51 away from the ABS, the structure being characterized by the dimensions of the various sub-structures that, together, make up the P1 pedestal. The recessed region 51 of the P1 pedestal is filled with a nonmagnetic material.

1st embodiment

The way the new design feature works is explained by the illustration in FIG. 6. The

closed arrows denote the flow of flux from the P1 to the P2 pole for a low or medium write current of less than 40 mA. However, for a high write current (larger than 40 mA), the P1 pedestal becomes magnetically saturated in constricted region 45 (P1B), causing excess flux to go through to P2. from the backside of 62 (P1C) as indicated by open white arrow 61. This prevents said excess flux from appearing at the ABS at the P1 shoulder.

Our preferred dimensions for the various elements that make up P1 in FIG. 6 are: summarized as follows:

W1 between about 1.4 and 2.6 microns; W2 between about 0.6 and 2 microns; H1 between about 0.6 and 2.5 microns; H2 less than about 3 microns; H3 between about 0.5 and 3 microns; and H4 between about 0.5 and 2 microns.

FIG. 7, like prior art FIG. 4, shows the cross track profiles of the PI shoulder field in a planar write head with the P1 structure of FIG. 6. In the region of write currents less than 40 mA, both P1 shoulder field profiles are quite similar. But in case of high write current of 60 mA (curve 75), the P1 structure of the invention shows much smaller field strength (compare with curve 45 in FIG. 4).

FIG. 8 shows the write current dependence of the maximum write field, which is derived from the write gap, for both P1 structures. Both write fields show similar values up

to a 40 mA write current but in the range over 40 mA write current, the write field of the conventional P1 continues to increase with increasing the write current (curve 81) while the write field of the invention's P1 levels off and becomes insensitive to the write current.

This reduced sensitivity to such high write current is very effective to prevent a write resolution degradation and magnetic write width growth due to the over saturation of a recording medium.

FIG. 9 shows the write current dependence of the P1 shoulder field. The invention's P1 structure (curve 92) shows a smaller P1 shoulder field for write currents over 30 mA than seen for shoulder fields in a prior art device (curve 91), this tendency becoming more conspicuous especially for high write currents. Consequently the invention's P1 can provide less adjacent track erasures (FIG. 9) as well as less degradation of the write resolution and a stable magnetic write width (compare curve 102 of the invention with prior art curve 101 in FIG. 10).

Although we have employed the first embodiment, as shown in FIG. 6, as a vehicle for explaining the modus operandi of the invention, it will be understood that variations on this basic design are possible without reducing the effectiveness of the invention. With this in mind, we provide examples of three more embodiments below.

2nd embodiment

This is illustrated in FIG. 11. Preferred dimensions for the various elements of which it is composed are as follows:

W1 between about 1.4 and 2.6 microns; W2 between about 0.6 and 2 microns; H1 between about 0.6 and 2.5 microns; H2 less than about 3 microns; H3 between about 0.5 and 3 microns; and H4 between about 0.5 and 2 microns.

3rd embodiment

This is illustrated in FIG. 12. Preferred dimensions for the various elements of which it is composed are as follows:

W1 between about 0.6 and 2 microns; W2 between about 1.4 and 2.6 microns; H1 between about 0.6 and 2.5 microns; H2 between about 1 and 5 microns; and H3 between about 0.5 and 2 microns.

4th embodiment

This is illustrated in FIG. 13. Preferred dimensions for the various elements of which it is composed are as follows:

W1 between about 0.6 and 2 microns; W2 between about 1.4 and 2.6 microns; H1 between about 0.6 and 2.5 microns; H2 between about 1 and 5 microns; and H3 between about 0.5 and 2 microns.

We conclude by noting that P1C (element 12 in various figures) can be shaped to have sloping sides (when viewed in the Y direction). Two examples of this are shown. In FIG.14, the slope is such that P1C is topped by a flat area that is 6 or 7 times the width of element 13. In FIG. 15 said slope is reduced so that the top surface of P1C is no wider than that of element 13.

What is claimed is: